PHYSICS PRACTICE QUESTION BANK
Topic: Nuclei & Atoms

Open Access Practice Bank

SECTION I: NUCLEI

26. Assume that an electron and a positron pair is formed from a gamma-ray photon having energy 3.0 MeV. Find the total kinetic energy of the positron and the electron that is formed.

(A) 2.98 MeV

(B) 1.98 MeV

(C) 19.8 MeV

(D) 0.98 MeV

27. Match LIST-I with LIST-II:

LIST-I	**LIST-II**
A. ${}_{0}^{1}\mathrm{n} + {}_{92}^{235}\mathrm{U} \rightarrow {}_{54}^{140}\mathrm{Xe} + {}_{38}^{94}\mathrm{Sr} + 2\,{}_{0}^{1}\mathrm{n}$	I. Fusion with high energy release
B. ${}_{1}^{2}\mathrm{H} + {}_{1}^{3}\mathrm{H} \rightarrow {}_{2}^{4}\mathrm{He} + {}_{0}^{1}\mathrm{n}$	II. Fission process
C. ${}_{1}^{2}\mathrm{H} + {}_{1}^{2}\mathrm{H} \rightarrow {}_{2}^{3}\mathrm{He} + {}_{0}^{1}\mathrm{n}$	III. Fusion releasing a neutron and ${}^{3}\mathrm{He}$
D. ${}_{1}^{3}\mathrm{H} + {}_{1}^{3}\mathrm{H} \rightarrow {}_{2}^{4}\mathrm{He} + 2\,{}_{0}^{1}\mathrm{n}$	IV. Fusion releasing two neutrons

(A) A-II, B-I, C-III, D-IV

(B) A-III, B-I, C-II, D-IV

(C) A-II, B-III, C-I, D-IV

(D) A-I, B-II, C-IV, D-III

28. Consider the nuclear reaction: ${}_{3}^{7}\mathrm{Li} + {}_{1}^{1}\mathrm{H} \rightarrow 2({}_{2}^{4}\mathrm{He})$. The relevant atomic masses are: $m({}_{3}^{7}\mathrm{Li}) = 7.0160\,\mathrm{u}$, $m({}_{1}^{1}\mathrm{H}) = 1.0078\,\mathrm{u}$, $m({}_{2}^{4}\mathrm{He}) = 4.0026\,\mathrm{u}$. Find the total energy released when 1.0 g of ${}_{3}^{7}\mathrm{Li}$ is completely consumed in this reaction along with sufficient amount of ${}_{1}^{1}\mathrm{H}$.

(A) 1.62×10^{10} J

(B) 4.25×10^{12} J

(C) 2.38×10^{11} J

(D) 8.90×10^{9} J

29. A free neutron at rest decays into three particles: a proton, an electron, and an anti-neutrino (${}_{0}^{1}\mathrm{n} \rightarrow {}_{1}^{1}\mathrm{p} + {}_{-1}^{0}\mathrm{e} + \bar{\nu}$). The rest masses are $m_n = 939.5656\ \mathrm{MeV}/c^2$, $m_p = 938.2723\ \mathrm{MeV}/c^2$, and $m_e = 0.5109\ \mathrm{MeV}/c^2$. Find the amount of energy released in the reaction.

(A) 0.511 MeV

(B) 0.180 MeV

(C) 1.022 MeV

(D) 0.782 MeV

30. A $^{14}_{7}$N nucleus, when bombarded by an α-particle ($^{4}_{2}$He), converts into $^{17}_{8}$O according to the reaction $^{14}_{7}\mathrm{N} + {}^{4}_{2}\mathrm{He} \rightarrow {}^{17}_{8}\mathrm{O} + {}^{1}_{1}\mathrm{H}$. Given atomic masses: $m(^{14}\mathrm{N}) = 14.0030\,\mathrm{u}$, $m(^{4}\mathrm{He}) = 4.0030\,\mathrm{u}$, $m(^{17}\mathrm{O}) = 16.9990\,\mathrm{u}$, and $m(^{1}\mathrm{H}) = 1.0080\,\mathrm{u}$. Find the Q-value of the reaction.

(A) -0.931 MeV

(B) $+0.931$ MeV

(C) -1.930 MeV

(D) $+1.930$ MeV

31. If the nuclear radius of $^{27}_{13}$Al is 3.6 fm, the approximate nuclear radius of $^{64}_{29}$Cu is:

(A) 3.6 fm

(B) 4.8 fm

(C) 5.4 fm

(D) 6.2 fm

32. Two nuclei have mass numbers in the ratio 1 : 27. What is the ratio of their nuclear densities?

(A) 1 : 3

(B) 1 : 27

(C) 1 : 1

(D) 1 : 9

33. A star initially has 10^{40} deuterons. It produces energy via the processes $^{2}_{1}\mathrm{H} + {}^{2}_{1}\mathrm{H} \rightarrow {}^{3}_{1}\mathrm{H} + {}^{1}_{1}\mathrm{H}$ and $^{2}_{1}\mathrm{H} + {}^{3}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He} + {}^{1}_{0}\mathrm{n}$. If the average power radiated by the star is 10^{16} W, the deuteron supply of the star is exhausted in a time of order of (Given masses: $m(\mathrm{n}) = 1.008$ u, $m(^{4}\mathrm{He}) = 4.001$ u, $m(^{2}\mathrm{H}) = 2.014$ u, $m(\mathrm{p}) = 1.007$ u):

(A) 10^{12} s

(B) 10^{8} s

(C) 10^{16} s

(D) 10^{6} s

34. Energy released when two deuterons ($^{2}_{1}$H) fuse to form a helium nucleus ($^{4}_{2}$He) is: (Given binding energy per nucleon of $^{2}_{1}\mathrm{H} = 1.1$ MeV and for $^{4}_{2}\mathrm{He} = 7.0$ MeV)

(A) 12.4 MeV

(B) 23.6 MeV

(C) 25.8 MeV

(D) 5.9 MeV

35. In a nuclear fission process, a high mass nuclide ($A = 236$) with binding energy of 7.6 MeV/nucleon dissociates into middle mass nuclides ($A = 118$), having binding energy of 8.6 MeV/nucleon. The energy released in the process is:

(A) 216 MeV

(B) 256 MeV

(C) 196 MeV

(D) 236 MeV

36. Consider the reaction: $^{7}_{3}\mathrm{Li} + {}^{1}_{1}\mathrm{H} \rightarrow 2(^{4}_{2}\mathrm{He})$. The binding energy per nucleon of $^{7}_{3}$Li and $^{4}_{2}$He are 5.60 MeV and 7.06 MeV respectively. Find the energy released.

(A) 19.62 MeV

(B) 17.28 MeV

(C) 14.60 MeV

(D) 8.42 MeV

37. If the mass of a proton is m_p, a neutron is m_n, and a stable nucleus of ${}^{A}_{Z}\mathrm{X}$ has mass M, then its binding energy is:

(A) $[Zm_p + (A - Z)m_n - M]c^2$

(B) $[M - Zm_p - (A - Z)m_n]c^2$

(C) $[Zm_p + Am_n - M]c^2$

(D) $[M - Zm_p - Am_n]c^2$

38. The ratio of the nuclear volumes of two nuclei with mass numbers A_1 and A_2 is:

(A) $A_1^{1/3} : A_2^{1/3}$

(B) $A_1 : A_2$

(C) $A_1^2 : A_2^2$

(D) Independent of A_1 and A_2

39. In a nuclear fission reaction, when a heavy nucleus breaks up into lighter fragments, compared to the parent nucleus, the binding energy per nucleon of product fragments is:

(A) Lower, leading to lower stability

(B) Same, leading to equal stability

(C) Higher, leading to higher stability

(D) Lower, leading to higher stability

40. Calculate the total energy released when 1.0 g of mass is completely converted into energy.

(A) 9×10^{16} J

(B) 9×10^{10} J

(C) 3×10^{8} J

(D) 9×10^{13} J

41. If the binding energy per nucleon (B/A) for a nucleus increases, its stability:

(A) Increases

(B) Decreases

(C) Remains unchanged

(D) First increases then decreases

42. The helium nucleus (${}^{4}_{2}\mathrm{He}$) exhibits a mass defect of 0.0303 u. The binding energy per nucleon of helium nucleus is close to:

(A) 28.2 MeV

(B) 7.06 MeV

(C) 14.1 MeV

(D) 3.53 MeV

43. A nuclear reactor generates 32 MW of power. If each fission event releases 200 MeV of energy, the number of fissions occurring per second is:

(A) 10^{16}

(B) 10^{20}

(C) 10^{18}

(D) 10^{14}

44. Which of the following statements is TRUE regarding nuclear forces?

(A) They are short-range and charge-independent

(B) They are long-range and charge-dependent

(C) They obey inverse-square law like electrostatic forces

(D) They are weaker than gravitational forces at short distances

45. The mass of a $^{12}_{6}$C nucleus is exactly 12 u. If the mass of a free proton is 1.00728 u and a free neutron is 1.00866 u, the total binding energy of $^{12}_{6}$C is approximately:

(A) 92.16 MeV

(B) 7.68 MeV

(C) 89.09 MeV

(D) 4.61 MeV

46. The radius of a spherical nucleus of $^{27}_{13}$Al atomic mass number 27 is 3.6 fm. If another spherical nucleus has a radius of 4.8 fm, its mass number A will be:

(A) 32

(B) 125

(C) 216

(D) 64

47. In a nuclear reactor, fast neutrons produced in fission ($E_i = 2$ MeV) are slowed down to thermal energy ($E_f = 0.04$ eV) by colliding elastically with deuterium nuclei in heavy water (D_2O). Calculate how many head-on elastic collisions a neutron must undergo with deuterium nuclei to reduce its energy to thermal energy. [Take $\log_{10} 2 = 0.301$ and $\log_{10} 3 = 0.477$]

(A) 8

(B) 25

(C) 50

(D) 100

48. A heavy nucleus with mass number $A = 240$ and binding energy per nucleon of 7.6 MeV splits into two fragments of $A = 120$ each, with binding energy per nucleon of 8.5 MeV. The total energy released in the process is:

(A) 108 MeV

(B) 216 MeV

(C) 432 MeV

(D) 180 MeV

49. A certain nucleus has isotopic mass of 238.05 u and mass number of 238. The mass defect of this nucleus is 0.16 u. If energy equivalent of 1 u is taken as 931.5 MeV, the total binding energy of this nucleus rounded off to nearest integer is:

(A) 216 MeV

(B) 1798 MeV

(C) 149 MeV

(D) 500 MeV

50. Four protons are fused together to form a helium nucleus. The total mass defect in the process is found to be 0.028 u. The total energy liberated in this fusion reaction is approximately:

(A) 14.2 MeV

(B) 52.2 MeV

(C) 7.8 MeV

(D) 26.1 MeV

ANSWER KEY: NUCLEI

Q.No	Key	Q.No	Key	Q.No	Key	Q.No	Key	Q.No	Key
26	2	31	2	36	2	41	1	46	4
27	1	32	3	37	1	42	2	47	1
28	3	33	1	38	2	43	3	48	2
29	4	34	2	39	3	44	1	49	3
30	1	35	4	40	4	45	3	50	4

SECTION II: ATOMS

26. Speed of electron in fourth orbit for He^+ is (where v_0 is speed of electron in first Bohr orbit of H-atom):

(A) $2v_0$
(B) $v_0/2$
(C) $v_0/4$
(D) $4v_0$

27. The ratio between total acceleration of the electron in singly ionized helium atom (He^+) and hydrogen atom (both in ground state) is:

(A) 8
(B) 4
(C) 2
(D) 16

28. Magnetic moment due to the motion of the electron in the n^{th} energy state of hydrogen atom is proportional to:

(A) n^2
(B) n^3
(C) n
(D) n^4

29. The atomic number (Z) of an element whose K_α wavelength is λ is 11. The atomic number of an element whose K_α wavelength is 4λ is:

(A) 11
(B) 4
(C) 44
(D) 6

30. The shortest wavelength in the Lyman series of hydrogen spectrum is 912 Å. The shortest wavelength in the Balmer series is:

(A) 2280 Å
(B) 3648 Å
(C) 6566 Å
(D) 8208 Å

31. Suppose the potential energy between electron and proton at a distance r is given by $U = -\frac{ke^2}{3r^3}$. Using Bohr's theory, the velocity v of the electron in the n^{th} Bohr orbit is proportional to:

(A) n^3
(B) n^2
(C) n
(D) n^4

32. As the principal quantum number n is increased in hydrogen and hydrogen-like atoms, the quantities that are respectively increased and decreased are:

(A) Time period and radius

(B) Angular speed and energy

(C) Radius and velocity

(D) Angular momentum and radius

33. Hydrogen-like atoms of an element are all in a particular excited state, where potential energy of an electron is U_0. All the atoms reach ground state by emitting photons of all possible energies and the emission spectrum contains 28 wavelengths. If the kinetic energy of an electron in ground state is $-xU_0$, then x will be:

(A) 8

(B) 64

(C) 16

(D) 32

34. A hydrogen atom in its ground state absorbs 10.2 eV of energy. The angular momentum of the electron of the hydrogen atom will increase by the value of (Given $h = 6.6 \times 10^{-34}$ J s):

(A) 2.10×10^{-34} J s

(B) 1.05×10^{-34} J s

(C) 3.15×10^{-34} J s

(D) 4.20×10^{-34} J s

35. According to Bohr's theory, the moment of momentum (angular momentum) of an electron revolving in the 4^{th} orbit of hydrogen atom is:

(A) $\frac{2h}{\pi}$

(B) $\frac{8h}{\pi}$

(C) $\frac{h}{\pi}$

(D) $\frac{h}{2\pi}$

36. An electron rotates in a circle around a nucleus having positive charge Ze. The correct relation between total energy (E) of the electron to its potential energy (U) is:

(A) $E = 2U$

(B) $E = -2U$

(C) $2E = U$

(D) $E = U$

37. The energy of an electron in an orbit of Bohr's atom is -0.85 eV, where $E_0 = -13.6$ eV is the ground state energy. If L is the angular momentum of the electron in this orbit, h is Planck's constant, then $\frac{2\pi L}{h}$ is:

(A) 8

(B) 6

(C) 2

(D) 4

38. Atomic hydrogen emits a line spectrum consisting of various series. Which series of hydrogen atomic spectra lies in the visible region?

(A) Brackett series

(B) Balmer series

(C) Lyman series

(D) Paschen series

39. Consider the following statements:
Statement-I: In hydrogen atom, the frequency of radiation emitted when an electron jumps from lower energy orbit (E_1) to higher energy orbit (E_2) is given as $hf = E_1 - E_2$.
Statement-II: The jumping of electron from higher energy orbit (E_2) to lower energy orbit (E_1) is associated with frequency of radiation given as $f = (E_2 - E_1)/h$. This condition is Bohr's frequency condition.
In light of the above statements, choose the correct answer:

(A) Both Statement I and Statement II are true

(B) Both Statement I and Statement II are false

(C) Statement I is correct but Statement II is false

(D) Statement I is incorrect but Statement II is true

40. In hydrogen atom spectrum ($R \rightarrow$ Rydberg's constant):
A. The maximum wavelength of the radiation of Lyman series is $\frac{4}{3R}$.
B. The Balmer series lies in the visible region of the spectrum.
C. The minimum wavelength of the radiation of Paschen series is $\frac{9}{R}$.
D. The minimum wavelength of Lyman series is $\frac{1}{R}$.
Choose the correct answer from the options given below:

(A) A, B, C and D

(B) A, B and D only

(C) B and D only

(D) A and C only

41. The smallest wavelength of Lyman series is 911 Å. The difference between the largest wavelengths of Paschen and Balmer series is nearly:

(A) 1550 Å

(B) 1875 Å

(C) 1217 Å

(D) 1784 Å

42. Choose the correct statement regarding atomic models:

(A) In the ground state of Rutherford's model electrons are in stable equilibrium.

(B) An atom has a nearly continuous mass distribution in Rutherford's model.

(C) A classical atom based on Rutherford's model is doomed to collapse.

(D) Positively charged part of atom possesses most mass in Thomson's model but not in Rutherford's.

43. If an α-particle with energy 7.7 MeV is bombarded on a thin gold foil, the closest distance to the nucleus it can reach is: (Atomic number of gold = 79 and $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ SI units)

(A) 3.85×10^{-14} m

(B) 2.95×10^{-14} m

(C) 3.85×10^{-15} m

(D) 2.95×10^{-15} m

44. Two electrons are moving in orbits of two hydrogen-like atoms with speeds 3×10^6 m/s and 2.5×10^6 m/s respectively. If the radii of these orbits are nearly same, then the possible order of energy states are respectively:

(A) 8 and 10

(B) 9 and 8

(C) 10 and 12

(D) 6 and 5

45. Consider the following statements:
A. Atoms of each element emit characteristic spectrum.
B. According to Bohr's Postulate, an electron in a hydrogen atom revolves in a certain stationary orbit.
Choose the correct answer:

(A) Statement A only

(B) Statement B only

(C) Both A and B

(D) Neither A nor B

46. $\sqrt{d_1}$ and $\sqrt{d_2}$ are the impact parameters corresponding to scattering angles 60° and 90° respectively when an α-particle approaches a gold nucleus. For $d_1 = xd_2$, the value of x is:

(A) 3

(B) 1

(C) 9

(D) $\sqrt{3}$

47. A beam of monochromatic light is used to excite the electron in Li^{2+} from the first orbit to the third orbit. The wavelength of monochromatic light is found to be $x \times 10^{-10}$ m. The value of x is: (Given $hc = 1242$ eV nm)

(A) 124

(B) 114

(C) 108

(D) 96

48. The wavelength of the characteristic X-ray K_α line emitted by a hydrogen-like element is 0.32 Å. The wavelength of K_β line emitted by the same element is $\frac{x}{100}$ Å. The value of x is:

(A) 32

(B) 18

(C) 36

(D) 27

49. The first member of the Balmer series of hydrogen atom has a wavelength of 656.1 nm. The wavelength of the second member of the Balmer series (in nm) is:

(A) 656

(B) 486

(C) 434

(D) 410

50. Hydrogen atom in its ground state is excited by means of monochromatic radiation of wavelength 97.5 nm. The longest wavelength amongst different spectral lines possible in the resulting spectrum is: (Given $hc = 12400$ eV Å)

(A) 188 nm

(B) 114 nm

(C) 216 nm

(D) 97.5 nm

ANSWER KEY: ATOMS

Q.No	Key	Q.No	Key	Q.No	Key	Q.No	Key	Q.No	Key
26	2	31	1	36	3	41	3	46	1
27	1	32	3	37	4	42	3	47	2
28	3	33	4	38	2	43	2	48	4
29	4	34	2	39	4	44	4	49	2
30	2	35	1	40	1	45	3	50	1